sandwiched therebetween.

[CLAIMS]

[Claim 1] A filter comprising:

a plurality of pieces of organic fiber which have 30-200mm fiber length and which are crimped, wherein the plurality of pieces of organic fiber are oriented;

a rodlike fiber-bundled body which is obtained by forming a plurality of point-bonding dots between fibers;

a filter medium which is produced by cutting the rodlike fiber-bundled body into 3-50mm lengths, wherein the filter medium is packed in layers in a filter tank such that a supporting body in the filter tank is brought into contact therewith;

an expansion part for the filter medium which is provided such that the filter medium can freely float and expand when washing the filter medium;

a feed pipe for supplying liquid to be filtrated to the filter tank;

a clean liquid drawing out pipe which is provided at a side opposite from the filtrate feed pipe such that the filter medium layer is sandwiched therebetween; and

a liquid feed pipe for washing the filter medium which is provided at a side opposite from the filtrate feed pipe such that the filter medium layer is sandwiched therebetween.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of Industrial Application] The present invention relates to a filtration apparatus. The invention particularly relates to a high-speed filter for filtrating

activated sludge sedimentation treated water, coagulating sedimentation treated water, river surface water, wastewater from fish firms, and the like by utilizing a fibrous water-treating material for removing floating bodies and suspended solids existing in liquid such as wastewater.

[0002]

[Prior Art] Conventionally, filter paper, filter cloth, wire gauze, sand, ceramics, and the like have been used as a filter medium for a filtration apparatus. In liquid filtration using a sheet-like material such as filter paper, filter cloth, and wire gauze, because floating bodies and suspended solids in the liquid to be filtrated adhere to a surface of the filter medium thereby clogging it, the filtration flow rate drops over time and filtration efficiency is reduced. In such a sheet-like material, it is difficult to remove suspended solids which have adhered to the surface and to regenerate and reuse the filter medium. On the other hand, in internal filtration using a sedimentary layer of particulate matter such as sand or ceramics, the filtration rate is slow, filtration accuracy is limited, and the clarity of filtrate is poor, although a reduction in the filtration flow rate is small. Moreover, because the filter medium is of high specific gravity, large quantities of washing liquid and power are required at the time of backwash, granulation of the filter medium by the backwash may occur, and the amount of the filter medium may be reduced.

[0003] Therein, a method as disclosed in Japanese Patent Publication No. 62-11637 has been proposed, for example, wherein the filter medium is selected as necessary from organic fibers without crimps such as natural fiber,

regenerated fiber, and synthetic fiber and from inorganic fibers without crimps such as glass fiber or metal fiber and from a mass of fiber produced by tangling the fibers without crimps by a proper method. There is also a filter as disclosed in Japanese Patent Publication No. 62-55885, for filtration using a filter medium formed from an oval-spherical mass of fiber having 5-50 mm fiber lengths which is produced by interlacing organic fibers without crimps and which has a maximum diameter of 5 to 100 mm.

[0004]

[Problems to be Solved by the Invention] These masses of fiber have tangled structures because the fibers without crimps are tangled with each other. If a filter medium layer is formed using these masses of fiber as a filter medium and a solvent containing suspended materials is filtrated by using the filter disclosed in Japanese Patent Publication No. 62-55885, filtration needs to be stopped in order to wash, i.e., backwash the filter medium when the filter medium layer is clogged with caught suspended materials and filtration performance starts to drop. However, in these masses of fiber filaments are not joined to each other, and because the fibers are without crimps, the fibers are tangled loosely. Therefore, the fibers are likely to become untangled from each other when they are backwashed in the filter. After repeated use, the masses of fiber become smaller, filtration effect diminishes, and the filaments which have fallen off are mixed into filtrated water. Moreover, because fibers are not uniformly packed inside the mass of fiber produced by the above method, there are voids inside the mass. After filtration, the suspended materials adhere and remain in the voids and it is difficult to sufficiently wash the

filter medium. Furthermore, it is difficult to continuously produce the fiber masses and productivity of the filter medium is low. The produced fiber mass is likely to vary in size over a wide range according to the lengths and thicknesses of the filaments.

[0005] If a fiber mass is produced by the above method by using fibers without crimps and of fineness of 10 denier or smaller, only a rodlike fiber mass can be formed and it is hard to handle as a filter medium. On the other hand, if the fiber mass is produced by the above method using fibers with crimps, only a string-shaped or a large tangled mass can be produced with a certain to fiber, and is not sufficiently suitable for use as a filter medium.

[0006] Therefore, in view of the above problems, it is an object of the present invention to provide a filter capable of easily washing a filter medium and treating a large quantity of liquid by utilizing a fibrous water treating material.

[0007]

[Means to Solve the Problems] To achieve the above object, according to the present invention, there is provided a filter comprising a plurality of pieces of organic fiber which have 30-200mm fiber length and which are crimped, wherein the plurality of pieces of organic fiber are oriented; a rodlike fiber-bundled body which is obtained by forming a plurality of point-bonding dots between fibers; a filter medium which is produced by cutting the rodlike fiber-bundled body into 3-50mm lengths, wherein the filter medium is packed in layers in a filter tank such that a supporting body in the filter tank is brought into contact therewith; an expansion part for the filter medium which is provided such that the filter medium

can freely float and expand when washing the filter medium; a feed pipe for supplying liquid to be filtrated to the filter tank; a clean liquid drawing out pipe which is provided at a side opposite from the filtrate feed pipe such that the filter medium layer is sandwiched therebetween; and a liquid feed pipe for washing the filter medium which is provided at a side opposite from the filtrate feed pipe such that the filter medium layer is sandwiched therebetween.

[0008] The water treating material used in the filter of the invention can be produced by the following method. Organic fibers having 30-200mm fiber length and crimps are oriented in a sliver form, many point-bonding dots are formed between the oriented fibers to form the fibers into a rodlike body, and then the rodlike body is cut into 3-50mm lengths. A hot-melt adhesive is preferably used for forming the point-bonding dots between the fibers. The adhesive may be in particulate or fibrous shapes. If hot-melt fiber is used as the adhesive, the fiber is mixed in advance into the fiber bundle or the fiber used in the invention is formed from one having hot-melt characteristic. In order to form the point-bonding dots in the rodlike fiber-bundled body, a method in which a particulate adhesive or plasticizer is held in the fiber-bundled body can be used effectively besides the above method using thermal bonded fiber. When such a water treating material is packed in the filter, it is preferable that the length is substantially the same as a diameter of the water treating material. This is because anisotropy is reduced in packing of the water treating material and the material can be packed in the filter without creating abnormal voids if the water treating material in this shape is used.

[0009] The diameter of the water treating material formed from round rodlike continuous formed bodies is preferably 3 mm or larger and 50 mm or smaller. If the diameter of the water treating material is smaller than 3 mm, fibers are likely to fall off in a backwash process. On the other hand, if the diameter is larger than 50 mm, abnormal voids are likely to be created when the water treating material is packed in the filter. Once abnormal voids are created in a filter layer, the voids are hard to sufficiently fill up even by compressing the filter layer and therefore filtration performance drops and formation of the water treating material becomes difficult.

[0010] Because fibers with crimps in the fiber-bundled body are partially bonded to each other, the water treating material used in the invention includes uniform voids inside itself. By reducing the size of the voids by compression, the filtration effect can easily be increased. If the material is uncompressed, it is easily restored to its original shape and the fibers do not fall off when backwashing. The round rodlike formed bodies can be produced by utilizing a part of a normal spinning process. For example, a card web is sprayed with an adhesive or plasticizer and is hot-air preheated in a state of a card sliver. A solvent is supplied to a surface of bonded fiber where necessary and the fiber is passed through a cylindrical heating body, compressed, and cooled to thereby be formed continuously. After the fiber is formed into a fibrous rodlike body, the body is cut to thereby produce the water treating material.

[0011] In the filter of the present invention, the thickness of the filter layer formed from the water treating material can be set arbitrarily as required but in

terms of filtration accuracy and uniformity of the stacked layers when the filter medium is restacked after washing is desirably 30 cm or greater and more desirably 80 cm or greater. The height of the filter medium expansion part provided above the filter medium layer and used in washing is preferably at least one-third or more that of the filter medium layer.

[0012] When filtration is carried out using the apparatus of the present invention, the perforated plate may be disposed under the filter medium layer wherein filtration is carried out by downflow from above, or perforated plates may be disposed on opposite sides of the filter medium layer wherein filtration is carried out by compressing from one side. This may be selected according to the size of particles of suspended solids included in the liquid to be filtrated, concentration of the suspended solids, and use of the clear liquid after filtration. In other words, if filtration is carried out using downflow from above, the apparatus is simple and cost is low. However, resistance from the flow of water passing through the fibrous water treating material accumulates in a lower layer, the degree of fiber compression increases in the lower layer, caught suspended solids are deposited in voids in the fiber over time to increase the resistance of the flow of water, pressure on the lower layer increases to press on the fiber, and the degree of fiber compression increases in the lower layer. As a result, the filtration accuracy increases but is inferior to filtration accuracy when the filter layer is compressed from one side, because minute particles are not caught.

[0013] Two perforated panels may be arranged on both sides of a filter bed, the filter bed being compressed from

one side. When wastewater is supplied from the compressed side into the filter bed, suspended solids are mainly caught by the compressed side portion of the filter bed, because the compressed side portion has high degree of fiber compression compared with the not compressed side portion. On the other hand, when wastewater is supplied from the not compressed side into the filter bed, suspended solids are caught in decreasing order of particle size, because wastewater flows from low degree of fiber compression to high degree of fiber compression. Accordingly, the filter does not clog up for a long time. In consideration of such filtration features, the filtration apparatus may be designed in view of the quality of liquid and the purpose of using the clear filtrate.

[0014] In addition, the size of a floating expansion part provided at the top of the filter medium layer may be adapted to meet the needs, in particular, to secure a space in which the filter medium can freely move from right to left or up and down by feeding washing liquid from beneath the filter medium layer for pushing up the filter medium with its flow rate. In this case, more cleaning effect can be achieved by feeding air from an air blowing pipe with vent holes. Figs. 1-3 show some embodiments of the filtration apparatus according to the present invention. Fig. 1 shows a filtration apparatus not compressing the fibrous filtration media. Fig. 2 shows a filtration apparatus compressing the filtration media from above. Fig. 3 shows a filtration apparatus compressing the filtration media from below. These filtration apparatus are all operated in a downflow mode. Each hole of a perforated panel has enough size to prevent the outflow of the filter medium. Providing with a blowing pipe is not indispensable,

but is preferable for operating the backwash more efficiently.

[0015] Next, details of the filter of the invention will be described with reference to the drawings. Perforated panels 3, 4 are provided in a filter tank 1 having a proper diameter and a fibrous filter medium 2 is put inside the panels. The upper perforated panel is for preventing a feed pipe for supplying liquid to be filtrated and the like from becoming clogged with the fibrous filter medium in backwash. The distance between the perforated panels 3, 4 is at least 1.3 times and preferably 1.5 times or greater the thickness of a filter medium layer so as to secure a space 5 in which each piece of the fibrous filter medium can expand freely in the backwash. Reference numeral 6 designates the feed pipe for supplying the liquid to be filtrated and reference numeral 7 designates a pipe for drawing out clean liquid and also for supplying washing water in the backwash. Reference numeral 8 designates a washing wastewater discharge pipe and reference numeral 10 a pipe for blowing air used for agitating the filter medium in the backwash.

[0016] The apparatus in FIG. 2 is similar to that in FIG. 1 but has a handle 11 with a screw 12 for compressing the filter medium at a top portion of the filter tank 1. The perforated panel 4′ is fixed under the screw 12 and a device transmitting upward and downward motions of the screw but not transmitting a rotational motion to the panel is connected. Reference numeral 13 designates a screw seat wherein the perforated panel 4′ moves up and down by turning the handle. During filtration, the perforated panel 4′ is moved down to apply a proper amount of compression. In the backwash, the perforated plate is

moved up to a position where the filter medium can be expanded.

[0017] The apparatus illustrated in Fig. 3 is also similar to that in Fig. 1. In Fig. 3, the solids in wastewater are caught in decreasing order of particle size, because the wastewater flows from low density portion to high density portion of the fibrous media. Accordingly, the filtration efficiency can be improved. However, the filtration apparatus shown in Fig. 3 has some problems that water sealing in the apparatus is relatively difficult.

[0018]

[Embodiments] Using the apparatus in FIG. 2, a high-speed filtration test on model wastewater in which chemical kaolin was suspended was conducted. In this test, a fiber bundle was cut into 12 mm length and used as a fibrous water treating material, the fiber bundle being produced by mixing 60% of normal 4 denier polyester staple fiber having 51mm fiber length and crimps with 40% of 4 denier core-sheath polyester thermal bonded fiber having 51 mm fiber length (e.g., Melty 4080 type made by UNITIKA LTD.) to obtain a card sliver, blowing hot air of 130°C on the card sliver, and then cooling it in a cylindrical pipe to form it into a rod shape of 12mm. The rodlike fiber bundle was 11.7 g in weight per meter and included 7.6% packed fiber and 92.4% voids.

[0019] The above water treating material was packed at a height of 100 cm in a cylindrical filter tank of a diameter of 300 mm and an SS removal rate was measured when a compression rate of the fibrous water treating material and a flow rate were changed and after 5-minute backwash. The concentration of kaolin was measured per JIS K010. Results are presented in Table 1.

[0020]

[Table 1]

No.	Item to be Studied	Original Water Pollution (p.p.m)	Compression Rate (%) of Fibrous Water Treating Material	Filtration Flow Rate (m/hour)	Outlet Water Pollution (p.p.m)	Removal Rate (%)
1	Change in Compression Rate	50	0	80	5.4	89.2
2	Change in Compression Rate	50	50	80	1.7	96.6
3	Backwash suitability	50	50	80	1.8	96.4

[0021] From Table 1, it can be seen that the area of the apparatus can be reduced because the filtration rate can be increased as compared with a prior-art sand filtration method and the like. It can be further seen that an extremely satisfactory filtration accuracy can be obtained by reducing the fineness of filaments forming the fibrous water treating material or by increasing the compression rate. Therefore, the filter of the invention is suitable for use in normal wastewater treating, e.g., treating of activated sludge precipitation upstream wastewater, rotating-disc upstream wastewater, and the like. Clean water filtrated by the filter can be used in a so-called reclaimed water system. In addition, clean water obtained by filtrating river water, lake water, and ground water can be used as they are or after adding a flocculant to them as industrial water or city water. Moreover, the filter can be applied to filtration and recycling of fish

breeding tank water or filtration and recycling of pool or bath water, and the like. Furthermore, by pressing an advantage that the filtration rate can be increased, the apparatus with a small area can be placed on a loading platform of a truck and moved in case of necessity.

[0022]

[Effects of the Invention] As described above, the filter of the invention has excellent effects. In other words, the filter has a simple structure, can be operated easily, and can continuously carry out the filtration with high accuracy without a large pass-through resistance of liquid. The filter medium can be washed easily and used repeatedly for a long time. The filter can be used as a filter for various purposes and has great industrial significance.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[FIG. 1] A figure showing an embodiment of a filtration apparatus of the present invention.

[FIG. 2] A figure showing another embodiment of the filtration apparatus of the present invention.

[FIG. 3] A figure showing yet another embodiment of the filtration apparatus of the present invention.

[EXPLANATION OF THE REFERENCE NUMERALS]

1 Filter tank
2 Fibrous water treating material (filter medium)
3 Lower perforated plate
3′ Lower perforated plate which can be moved up and down
4 Upper perforated plate
4′ Upper perforated plate which can be moved up and down
5 Filter medium expansion part
6 Feed pipe for supplying liquid to be filtrated
7 Drawing out pipe of clean liquid (feed pipe for

supplying washing liquid)

8 Washing wastewater discharge pipe

9 Air vent pipe

10 Air blowing pipe

11 Compression Handle

12 Shaft with screw for upward/downward movement

13 Screw seat